Global Coupled Atmosphere/Ocean Model for Climate and Seasonal Forecast Applications

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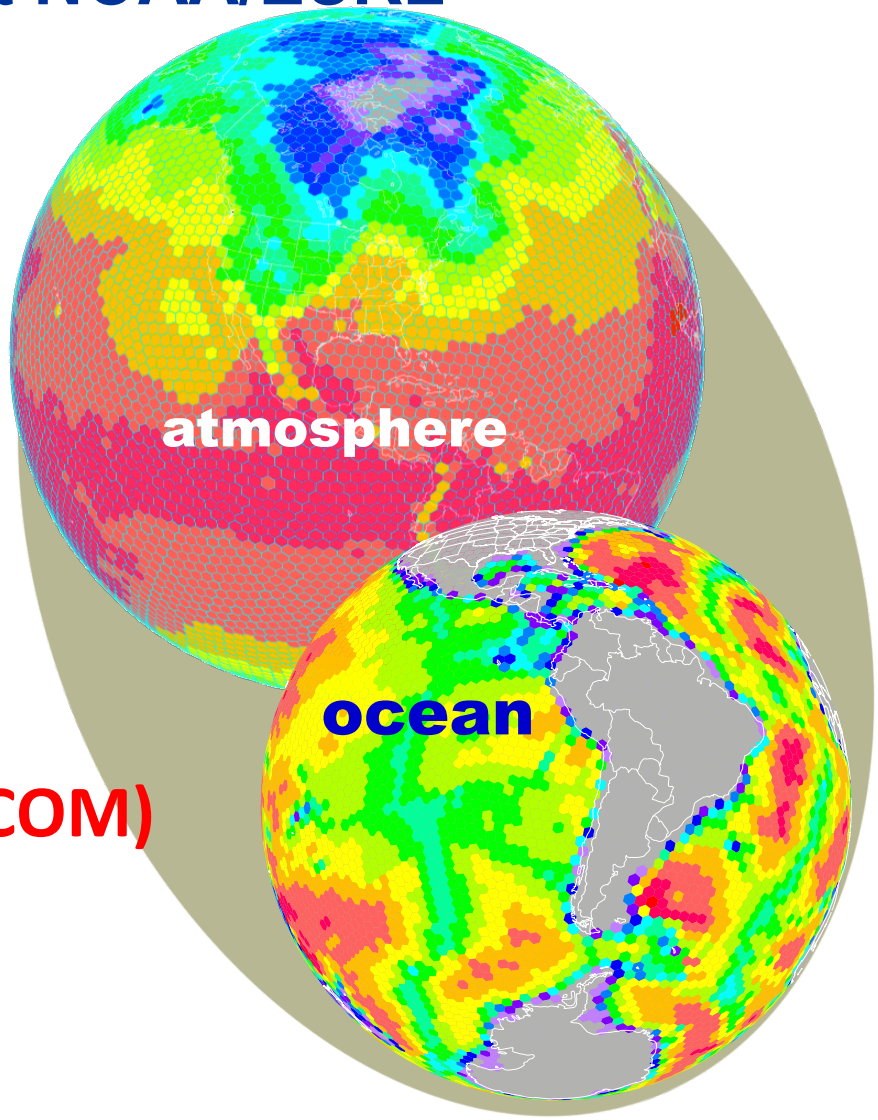
Coupled Atmospheric-Ocean Modeling on an Icosahedral Grid at NOAA/ESRL

Flow-following* finite volume Icosahedral Model (FIM)

Icosahedral Ocean Model (iHYCOM)



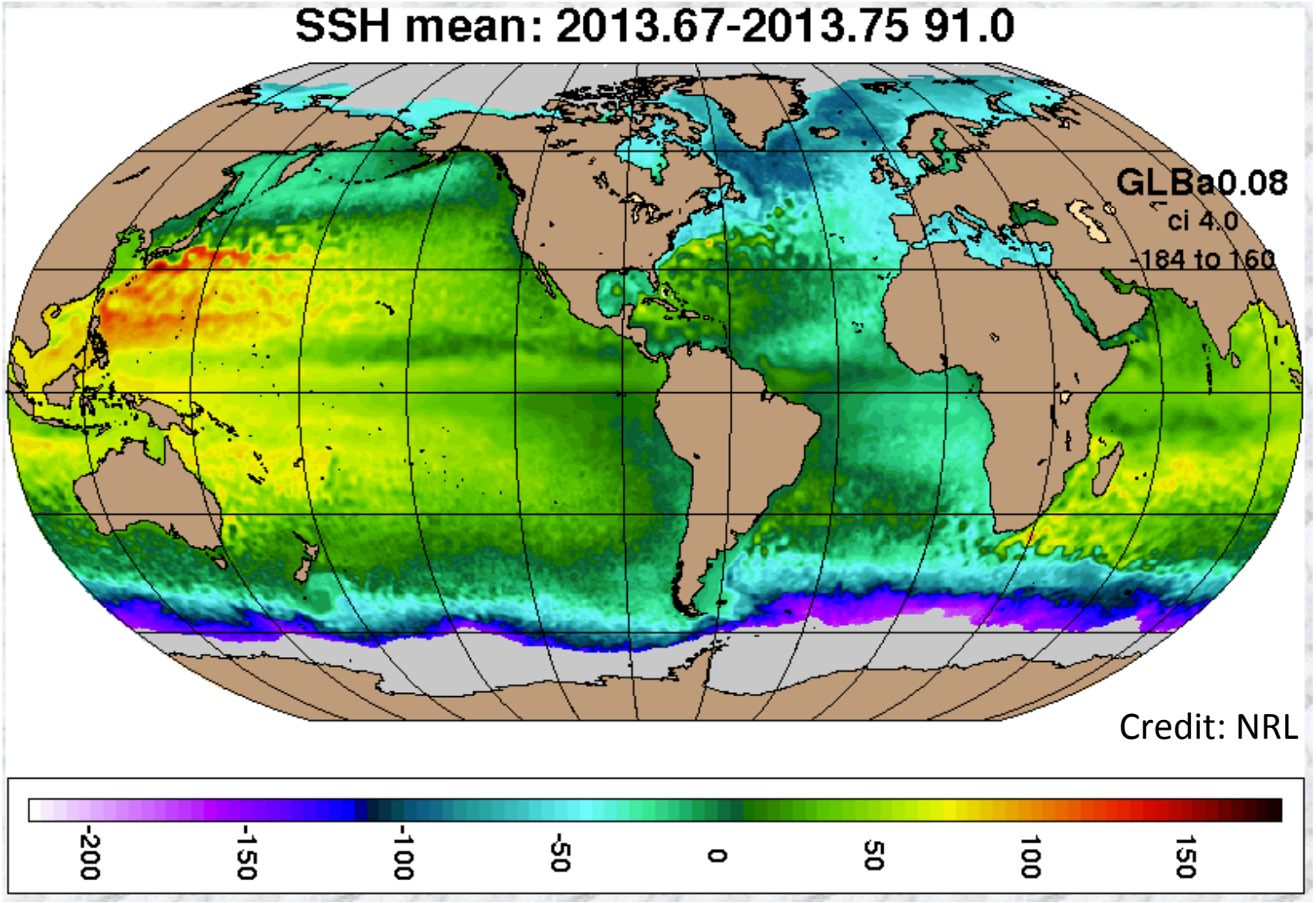
* flow-following = vertically quasi-Lagrangian

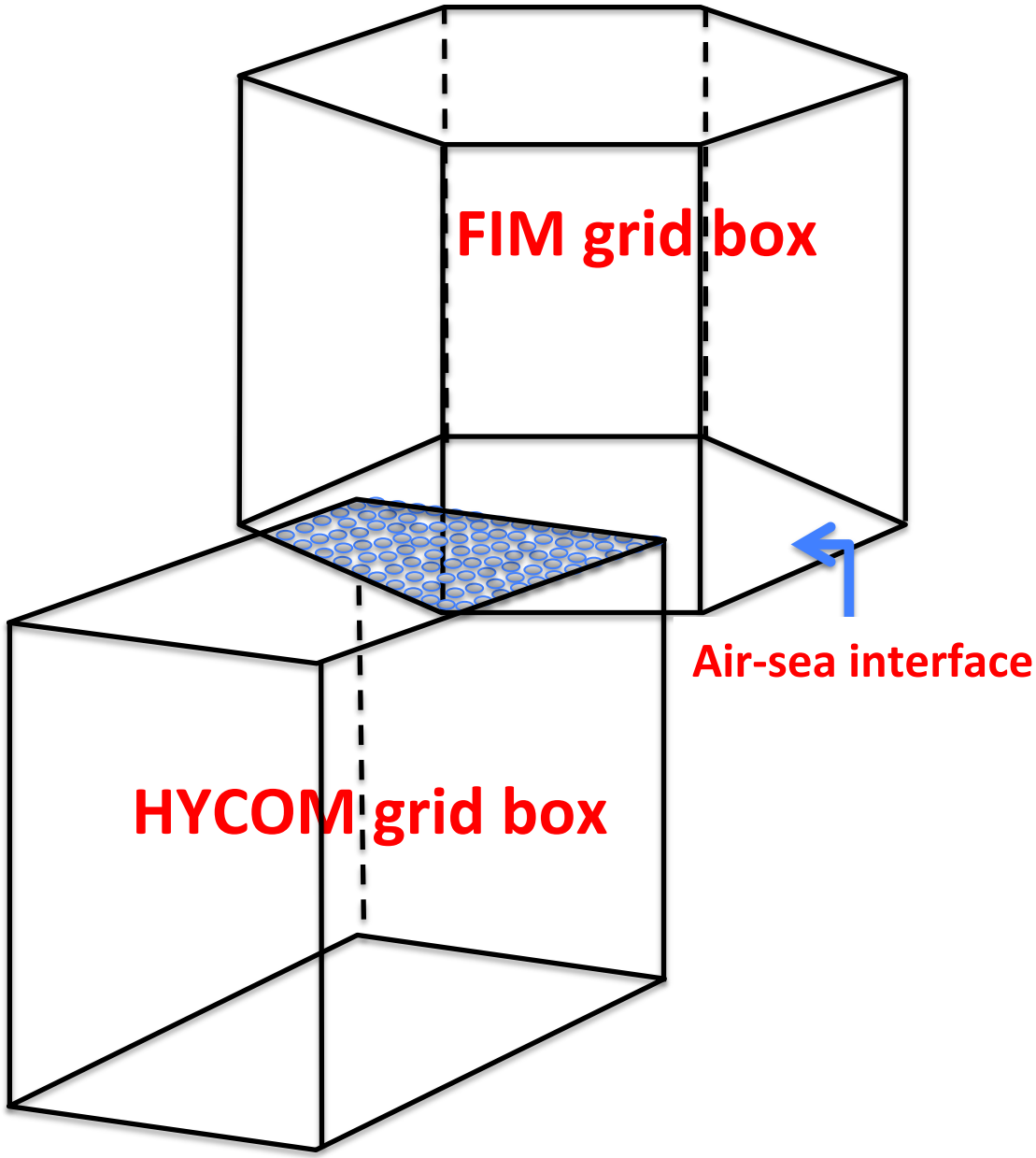
Coupled Atmosphere/Ocean at NOAA/ESRL

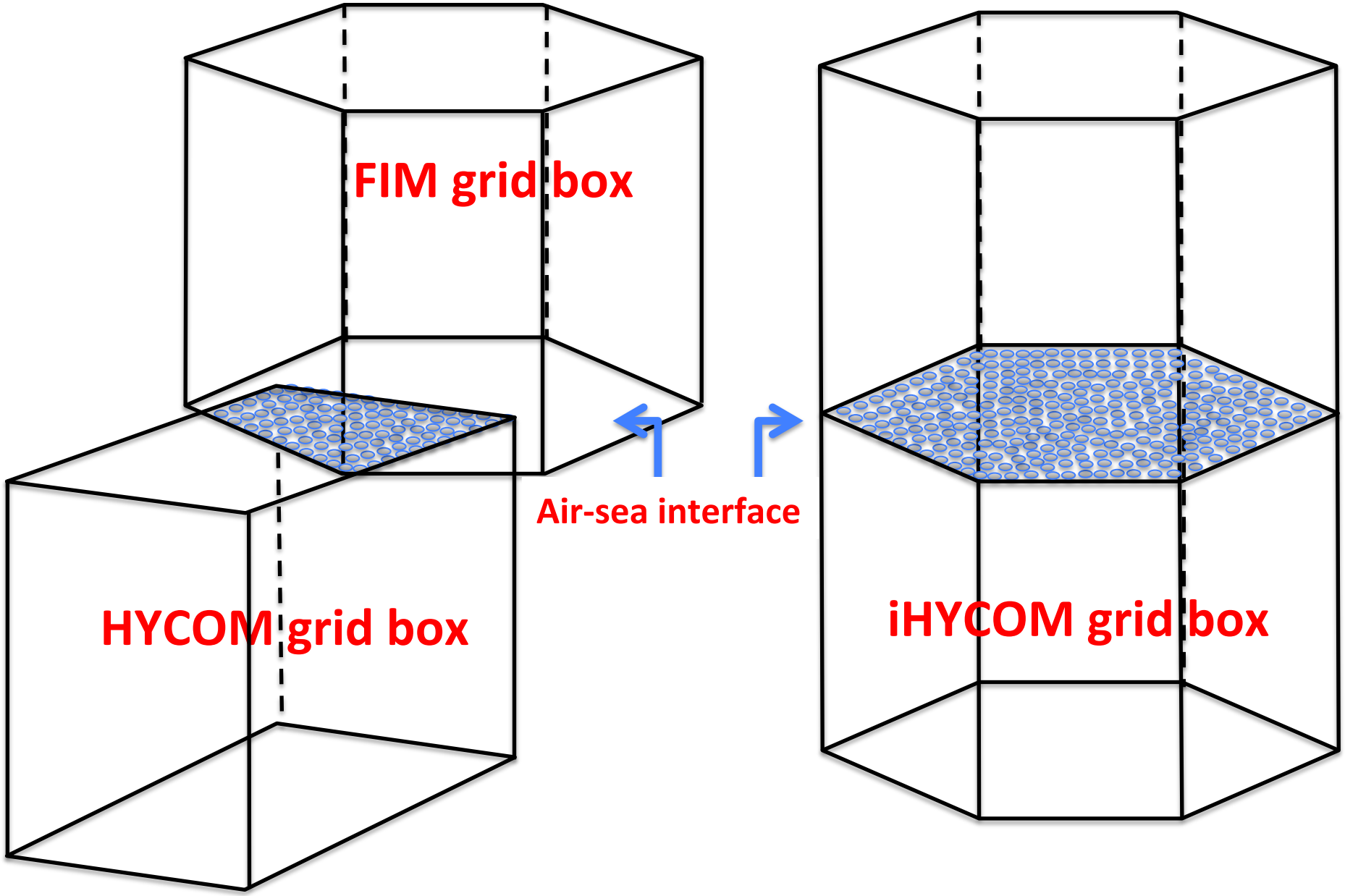
- **FIM atmospheric model**
  - Flow-following, finite volume, quasi-Lagrangian vertical coordinate, hydrostatic dynamics
  - On the icosahedral horizontal grid
  - Developed at NOAA/ESRL in collaboration with NCEP: GFS column physics
  - Running operationally with comparable scores to NCEP GFS **(http://fim.noaa.gov)**
- **iHYCOM ocean model: icos HYCOM**
  - HYCOM ocean model rewritten for icosahedral grid
  - Sharing multiprocessor environment developed for FIM
  - No need for spatial interpolation at the air-sea surface

HYCOM

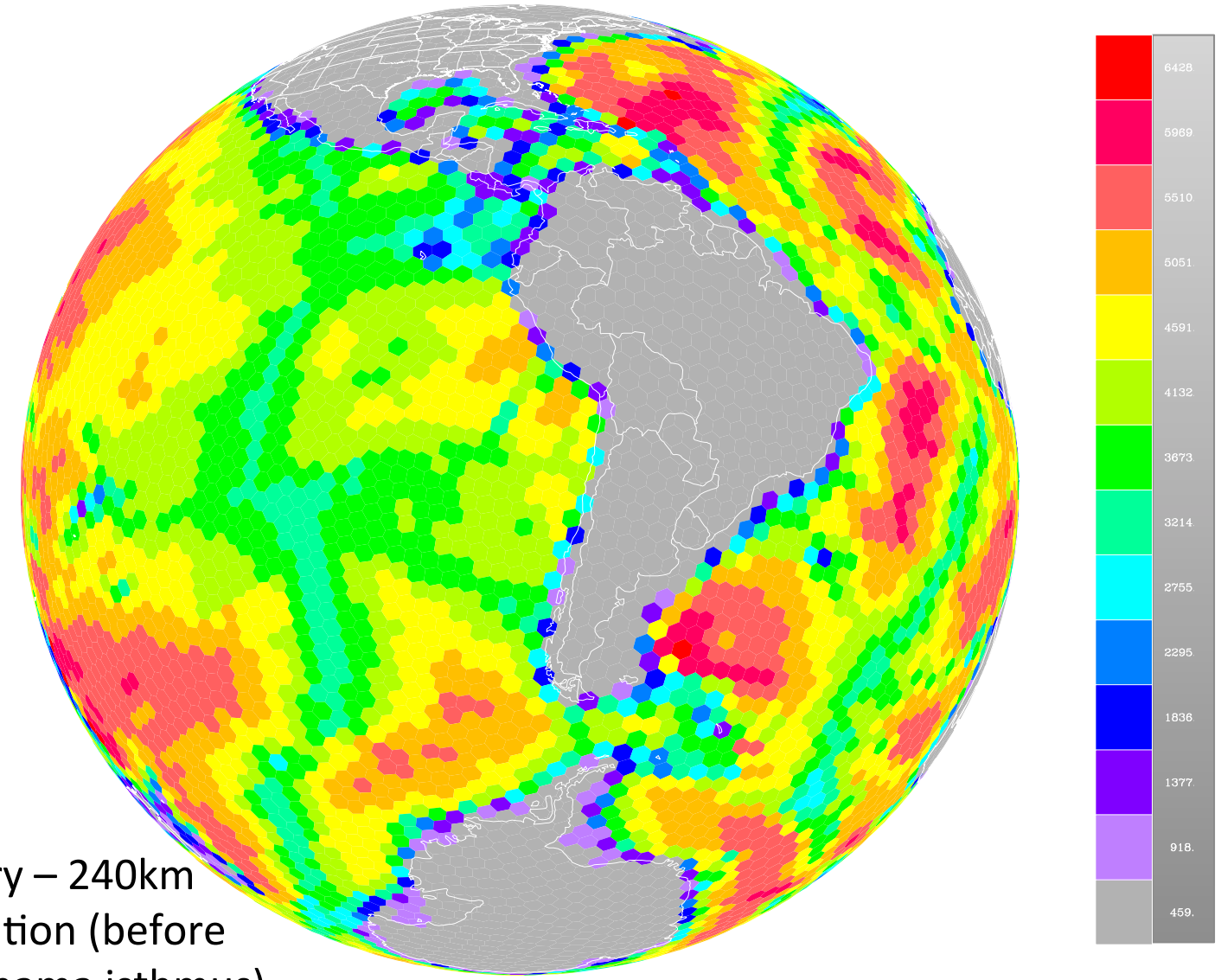
is short for HYBRID COORDINATE OCEAN MODEL




FIM grid box
Air-sea interface
HYCOM grid box


FIM grid box
HYCOM grid box
Air-sea interface
iHYCOM grid box

HYCOM on icosahedral grid: **iHYCOM**



Bathymetry – 240km grid resolution (before closing Panama isthmus)

Seasonal Experiments

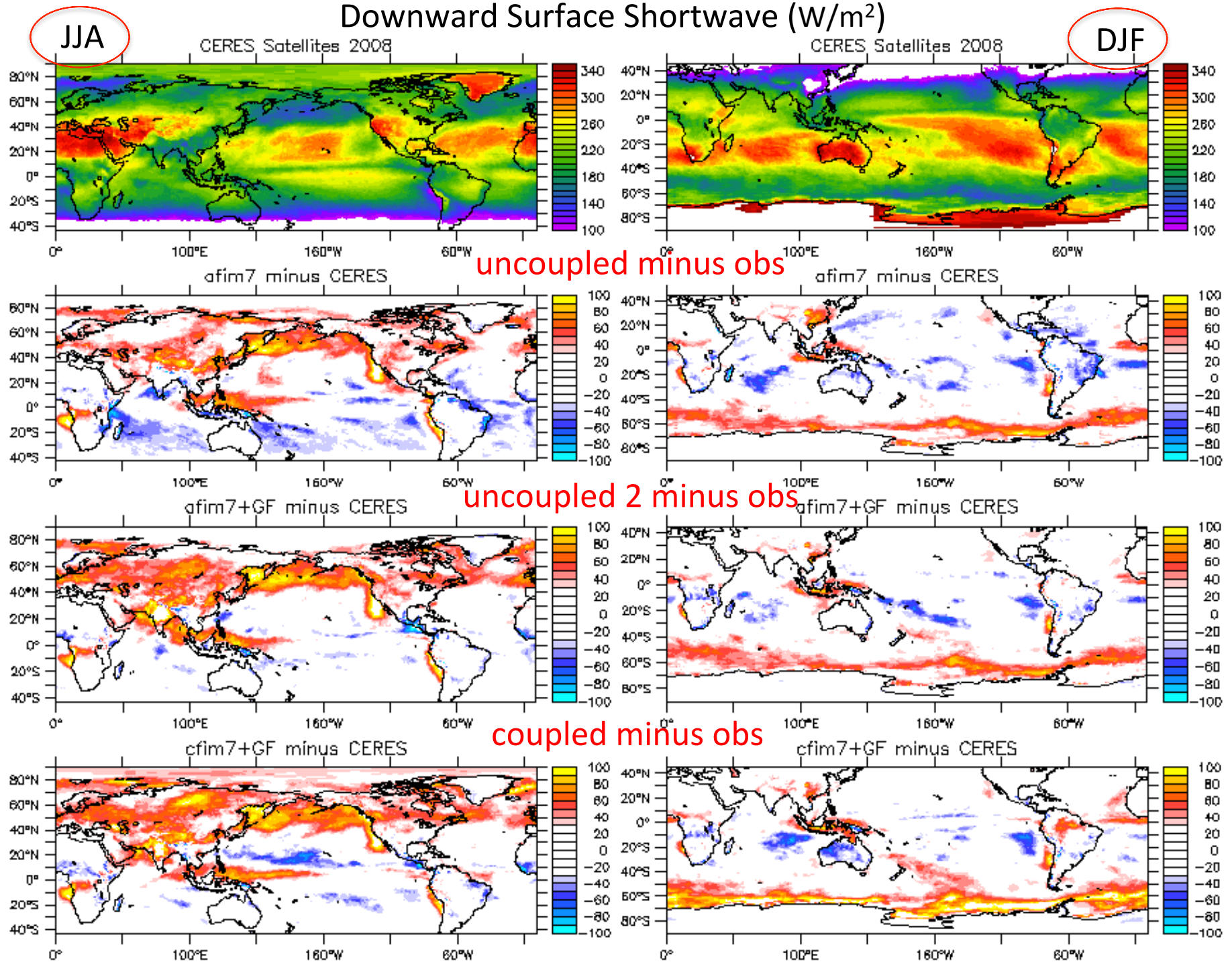
- ✧ Uncoupled atmospheric model FIM with observed SST, ice temperature & coverage;
  → near zero global heat & freshwater flux at surface

- ✧ Uncoupled atmospheric model 2 using the GF convection (Grell & Freitas 2013, *Atm.Chem.Phys.Disc.*);

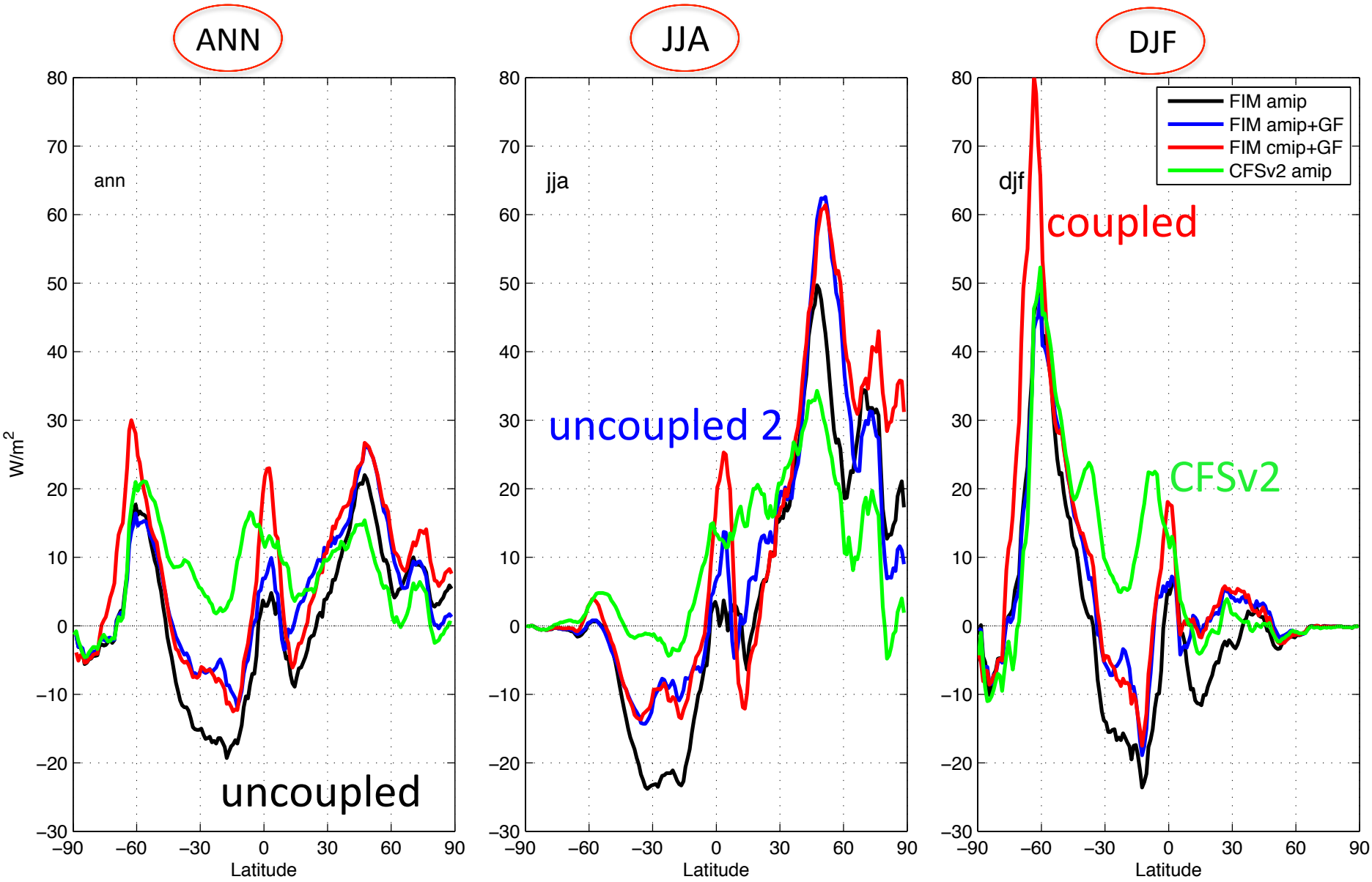
- ✧ Coupled atmospheric ocean model FIM (based on model 2) coupled to iHYCOM

All use 60km horizontal resolution & 64 layers

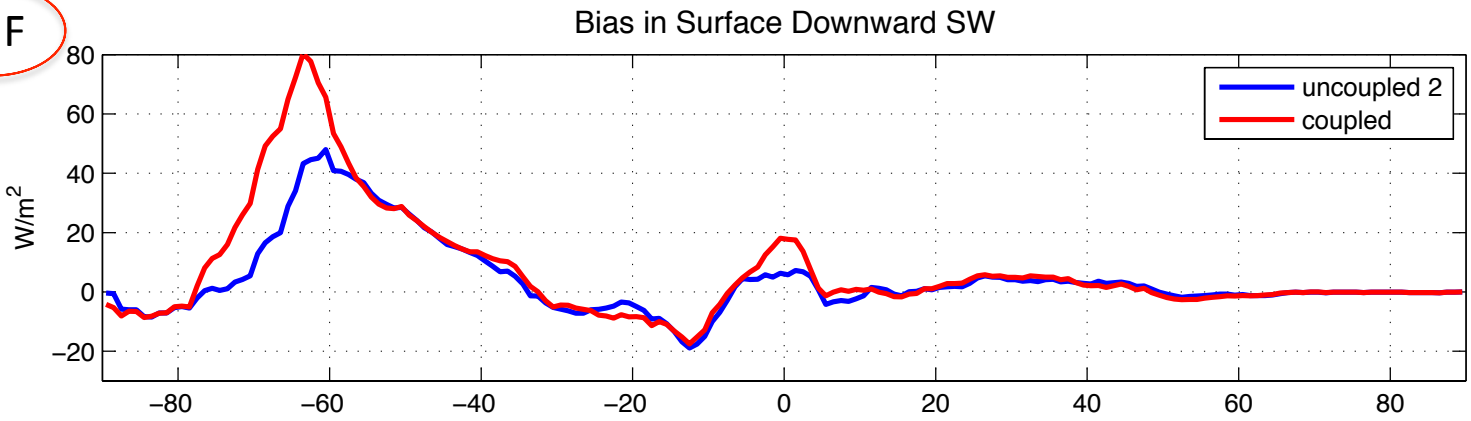
Downward Surface Shortwave (W/m²)

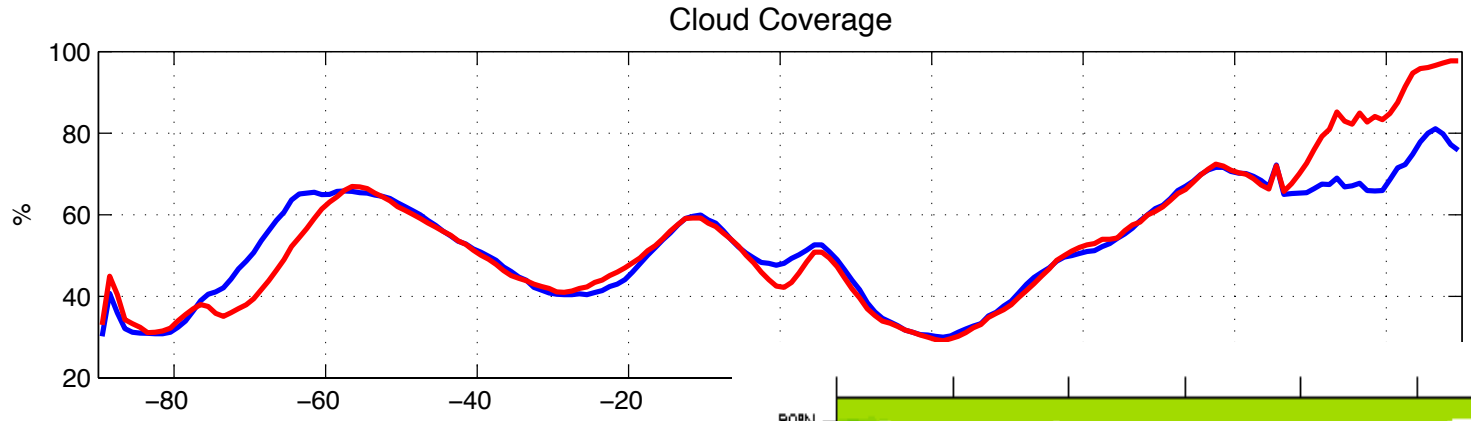


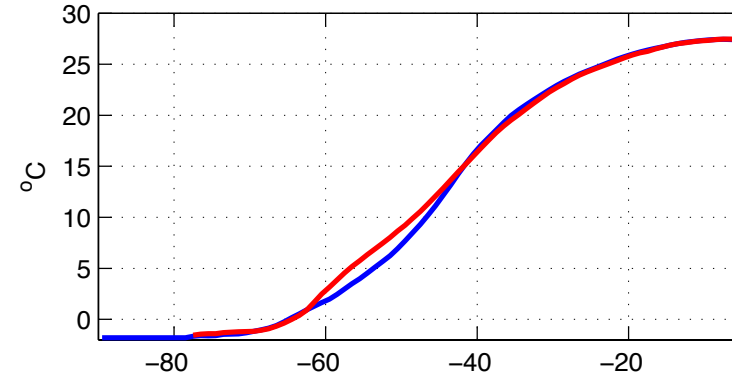
Biases in Zonal Surface Downward Shortwave Flux

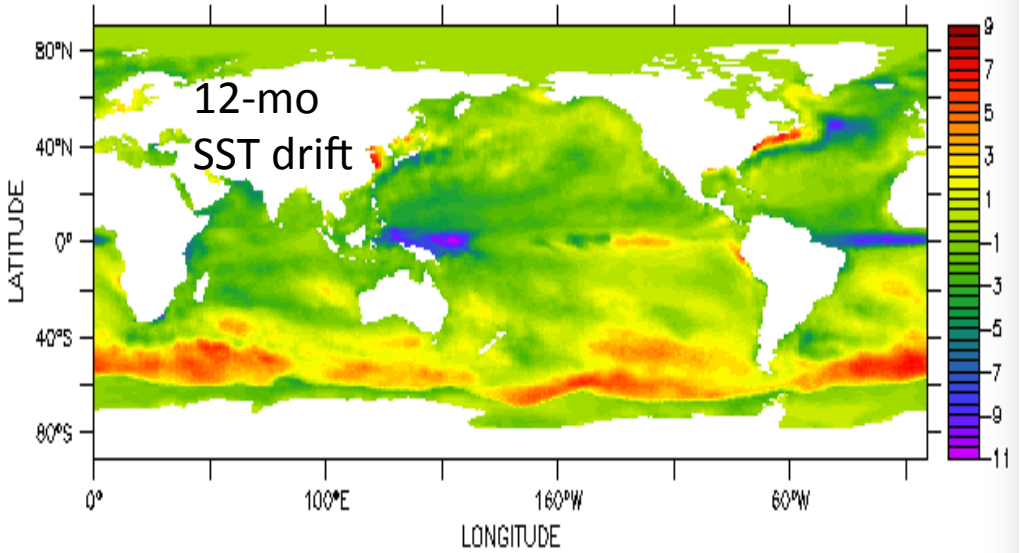


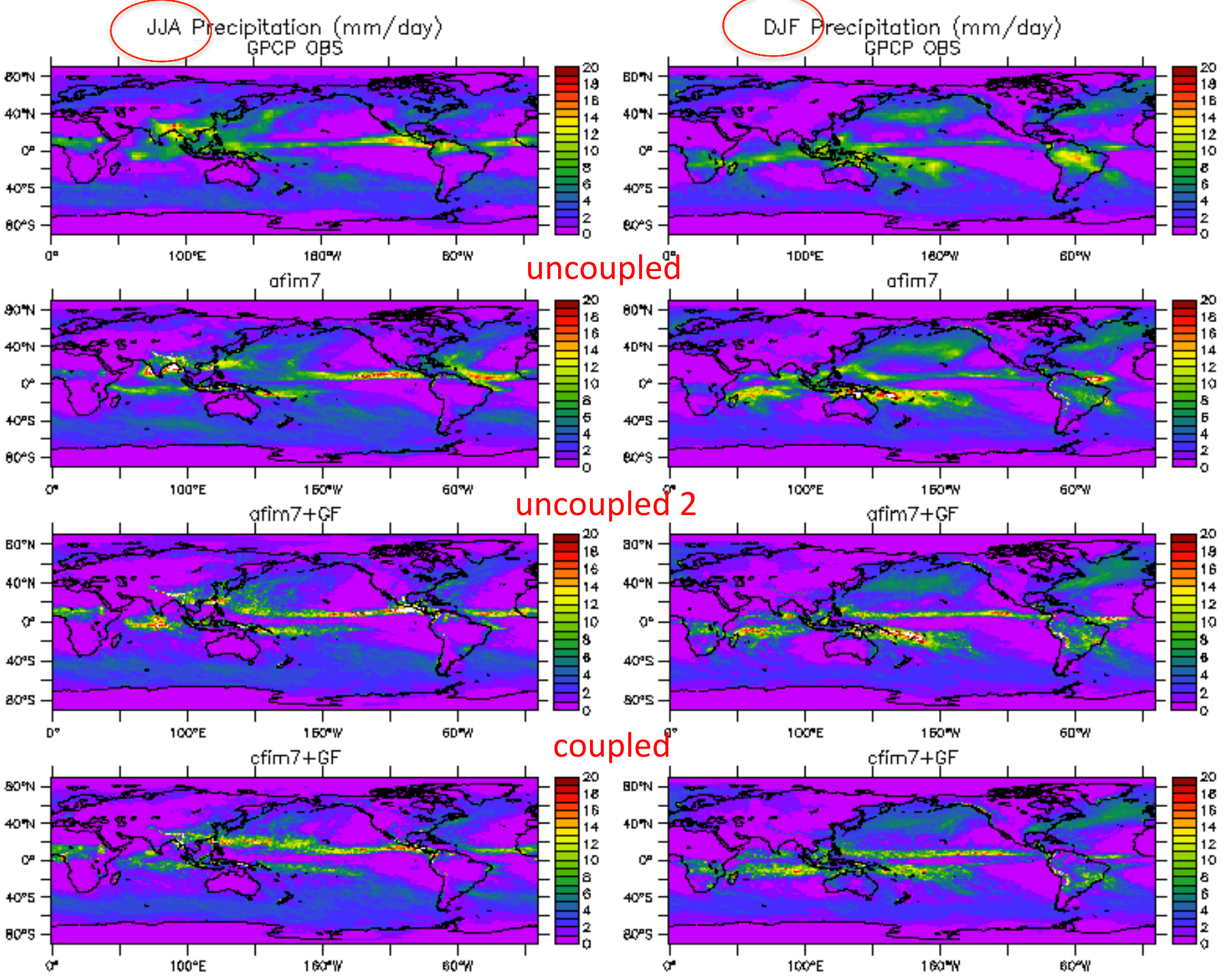
DJF


Bias in Surface Downward SW
uncoupled 2
coupled
W/m2
80
60
40
20
0
−20
−80
−60
−40
−20
0
20
40
60
80

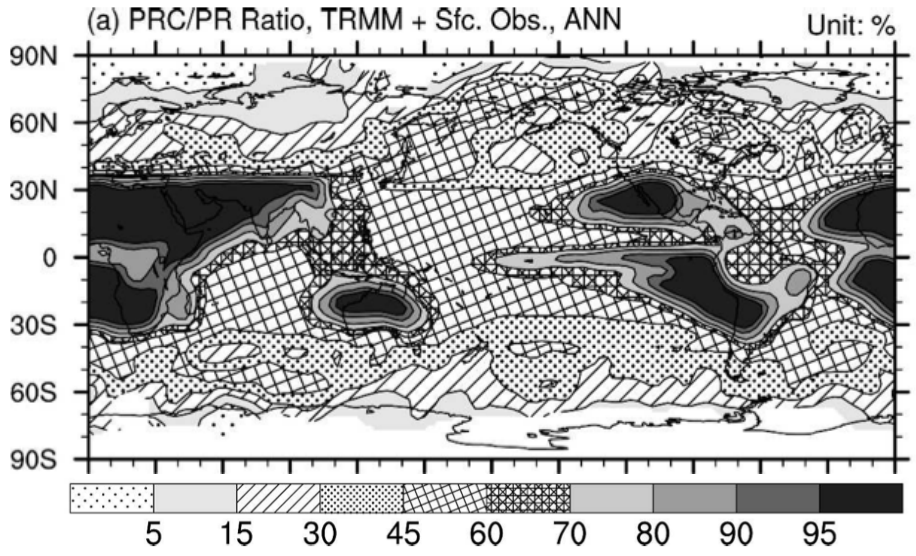

Cloud Coverage
%
100
80
60
40
20
−80
−60
−40
−20


°C
30
25
20
15
10
5
0
−80
−60
−40
−20

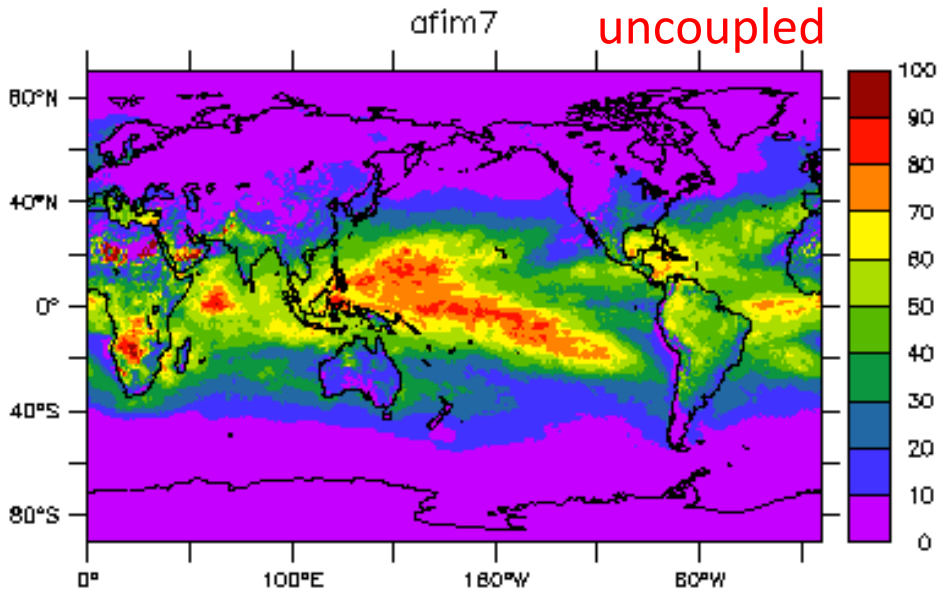

12-mo
SST drift
80°N
40°N
0°
40°S
80°S
LATITUDE
0°
100°E
160°W
60°W
LONGITUDE
9
7
5
3
1
−1
−3
−5
−7
−9
−11

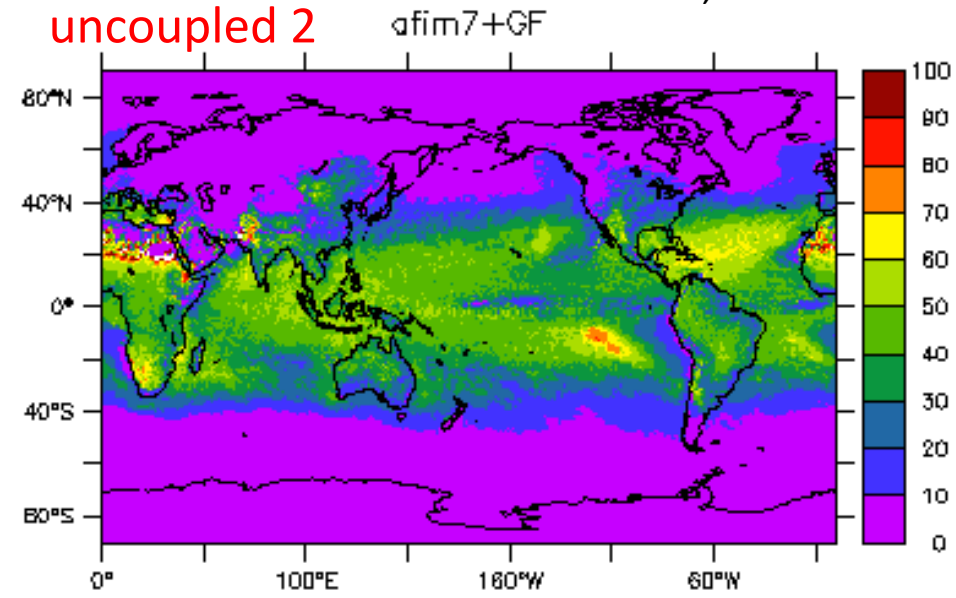

JJA Precipitation (mm/day)
GPCP OBS
DJF Precipitation (mm/day)
GPCP OBS
uncoupled
afim7
afim7
uncoupled 2
afim7+GF
afim7+GF
coupled
cfim7+GF
cfim7+GF
80°N
40°N
0°
40°S
80°S
0°
100°E
160°W
60°W
20
18
16
14
12
10
8
6
4
2
0

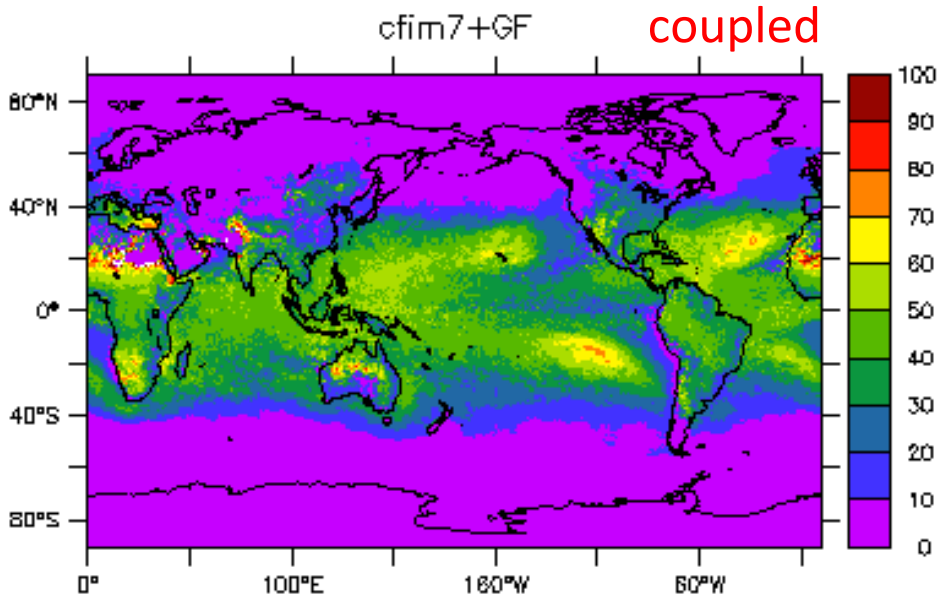
Ratio of Convective Precipitation to Total (%), ANN



Dai, J. Clim 2006







Summary

- Coupled FIM/iHYCOM model has the advantage of avoiding grid discontinuity at the air-sea surface, hence no need for interpolating flux coupler
- The mathematical similarity of the two models allows them to share dycore components and software engineering innovations
- FIM/iHYCOM is being developed to participate in NMME (National Multi-Model Ensemble), as well as for ESPC (Earth System Prediction Capacity) applications
- There are still large regional biases in surface shortwave flux & precipitation, most likely due to biases in cloud coverage
- Remaining climate drift in multi-year coupled runs reveals the need to further revise the column physics parameterizations in FIM/GFS/CFS via coordination between ESRL, EMC, and MAPP Process Teams